Managing early leaf spot and stem rot with reduced fungicide inputs on disease-resistant peanut cultivars

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ABSTRACT

Fungicide inputs are a costly but critical component of peanut production systems in the southeast U.S. Current strategies for reducing fungicide application numbers that are needed to control diseases on peanut include extending application intervals beyond a 2-wk schedule or implementation of a fungicide advisory, such as AU-Pnuts. In this study, fungicide programs with azoxystrobin, chlorothalonil, and tebuconazole, using different application schedules, were compared for the control of early leaf spot and stem rot. Application schedules were the standard 2-wk calendar interval, extended 3- and 4-wk intervals, and applications were made according to the AU-Pnuts leaf spot advisory. Studies were conducted on the disease resistant cultivars DP-1 in 2003 and C-99R in 2004 and 2005. The numbers of fungicide applications for the 2, 3, and 4-wk schedules were 7, 5, and 4, respectively, in 2003 and 2004, and were 6, 5, and 4, respectively, in 2005. One less fungicide application was scheduled according to AU-Pnuts than with the 2-wk calendar schedule in all three years, yet final early leaf spot levels with these schedules were similar in 2 of 3 years. With one fewer fungicide application, the 3-wk schedule had higher leaf spot levels than the AU-Pnuts advisory in 2003 and 2004. Further, when application intervals were extended from 2 wk to 3 or 4-wk intervals, a significant increase in early leaf spot was noted in two of three years. Despite these differences in early leaf spot severity, application schedule had limited impact on yield in this study. Application interval also had little impact on stem rot incidence, but incidence of this disease was lower with the azoxystrobin than chlorothalonil programs in 2 of 3 years. The azoxystrobin program significantly increased yield in 2 of 3 years compared with the chlorothalonil or tebuconazole programs. Yield was also higher for the tebuconazole compared with chlorothalonil programs in 2 of 3 years. When fungicide product and application costs were calculated, and those and other typical peanut production costs were deducted from estimated returns based on actual yields, the resulting net returns did not significantly differ among fungicide programs or application schedules.

Key Words: Expert system, AU-Pnuts advisory, chlorothalonil, tebuconazole, azoxystrobin, *Arachis hypogaea*, *Cercospora arachidicola*, *Sclerotium rolfsii*.

In Alabama, early and late leaf spot (caused by *Cercospora arachidicola* S. Hori and *Cercosporidium personatum* Berk. & M.A. Curtis, respectively) are common diseases that can prematurely defoliate peanuts and potentially reduce yield by as much as 50% (Shokes and Culbreath, 1997). To effectively control leaf spot diseases, fungicide applications should begin 30 to 40 d after planting and be repeated every 10 to 14 d until approximately 2 wk before the anticipated digging date (Weeks *et al.*, 2008). A total of 6 to 8 fungicide applications are typically made in a 2-wk calendar program.

Stem rot (caused by *Sclerotium rolfsii* Sacc.) is the most widespread and damaging soil-borne disease of peanut in Alabama. While average annual losses to stem rot have been estimated statewide at 5%, they can exceed 30% in some fields (Bowen *et al.*, 1996). Damaging outbreaks of stem rot in Alabama are most often seen in fields cropped every other year to peanut over an extended time period (Bowen *et al.*, 1996). To minimize yield loss due to stem rot, applications of fungicides with activity against both foliar and soil-borne diseases must be included. Fungicides with stem rot efficacy include tebuconazole, azoxystrobin, pyraclostrobin, flutolanil, fluoxastrobin, propiconazole + flutolanil, and prothioconazole + tebuconazole (Weeks *et al.*, 2008).

The number of fungicide applications per year can be reduced by lengthening application intervals or using a weather based program such as AU-Pnuts leaf spot advisory (Jacobi and Backman, 1995; Jacobi *et al.*, 1995). On the leaf spot-resistant cultivar Southern Runner (Gorbet *et al.*, 1987), lengthening intervals between chlorothalonil applications from 2 to 3 wk resulted in significantly higher levels of early and late leaf spot, but did not reduce yields (Jacobi and Backman, 1995). Simi-

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larly, an increase of early and late leaf spots on Southern Runner occurred when application intervals were lengthened from 2 to 3 wk using a program of chlorothalonil with tebuconazole, but a significant decline in yield occurred only in one of three years (Brenneman and Culbreath, 1994). In southwestern Alabama, where regular rainfall is very conducive to disease development, Hagan *et al.* (2006) reported increased leaf spot intensity but limited yield differences with extended application intervals with azoxystrobin and/or tebuconazole programs on the disease resistant cultivars C-99R (Gorbet and Shokes, 2002a) and DP-1 (Gorbet and Tillman, 2008). Monfort *et al.* (2004) also reported that yields obtained with 2 wk or extended calendar schedules with tebuconazole and azoxystrobin, but not with chlorothalonil alone, were similar on the peanut cultivars Georgia Green (Branch, 1996), C-99R and Florida MDR-98 (Gorbet and Shokes, 2002b). However, higher leaf spot levels were noted on all three cultivars when fungicide applications intervals were lengthened beyond 2 wk (Monfort *et al.*, 2004). Most recently, Woodward *et al.* (2008) reported a significant reduction in leaf spot control without a yield difference with a reduced program consisting of two fungicide applications (one pyraclostrobin and one tebuconazole) compared to a standard 2-wk calendar program with chlorothalonil alone, or one that included applications of pyraclostrobin, tebuconazole, and chlorothalonil.

The AU-Pnuts leaf spot advisory was designed to time fungicide applications to coincide with periods when weather patterns are conducive to the development of leaf spot diseases on peanut (Jacobi *et al.*, 1995). According to this advisory, fungicide applications are scheduled based on the number of accumulated rain or irrigation events ($>$ 2.5 mm within a 24 hr period) and the 5-d rainfall forecast. Regardless of the 5-d rainfall forecast, the first fungicide application is made no later than the sixth rain event after peanut seedlings first emerge. Beginning 10 d after any fungicide application, subsequent applications are recommended after the occurrence of: a) three rain events, b) a 5-d average rainfall forecast of $\geq$ 50%, or c) a combination of one or two rain events and a 5-d average rainfall forecast of 40% or 20%, respectively. Reductions of 1.25 fungicide applications per season (Jacobi *et al.*, 1995) were obtained with the AU-Pnuts advisory compared to a 2-wk schedule. Brenneman and Culbreath (1994) made two fewer fungicide applications in two of three years with AU-Pnuts compared with the standard 2-wk calendar schedule. Bowen *et al.* (2006) noted similar reductions in application numbers with AU-Pnuts, and reported a decline in early leaf spot control and yield in only one of three years. In south Texas, azoxystrobin, pyraclostrobin, and tebuconazole applied according to AU-Pnuts advisory, gave similar disease control and yield, compared to a 2-wk calendar program with chlorothalonil while reducing application numbers from seven to three (Grichar *et al.*, 2005). In contrast, application numbers for the 2 wk and AU-Pnuts advisory programs were similar in two of three years in Southwest Alabama where almost daily rainfall occurred throughout much of the summer (Hagan *et al.*, 2006).

In recent years, cultivars with partial resistance to leaf spot diseases and stem rot have been released and are widely planted. The late-maturing cultivars Southern Runner, Florida MDR 98, C-99R, and DP-1 have partial resistance to late, sometimes early leaf spot, and stem rot (Branch and Brenneman, 1996; Branch and Culbreath, 2008; Cantonwine *et al.*, 2002; Gorbet and Shokes, 2002; Hagan *et al.*, 2004; Hagan *et al.*, 2005, Monfort *et al.*, 2004, Woodward *et al.*, 2008). The medium-maturing cultivar Georgia-03L (Branch, 2004) also has better disease resistance than the most widely planted cultivar, Georgia Green (Branch and Culbreath, 2008; Hagan *et al.*, 2005; Woodward *et al.*, 2008). When used in combination with a disease resistant cultivar, the fungicide azoxystrobin, which has excellent activity against leaf spot diseases and stem rot (Bowen *et al.*, 2006; Hagan *et al.*, 2006; Monfort *et al.*, 2004) should allow the extension of application intervals beyond 2 wk without yield loss. In this study, we evaluated reduced applications of fungicide programs with azoxystrobin, chlorothalonil, and tebuconazole for the control of early leaf spot and stem rot and yields of the late maturing, disease-resistant cultivars DP-1 and C-99R.

Material and Methods

On 14 May 2003, 16 May 2004, and 23 May 2005, peanuts were planted at a rate of 17 seed/m in Dothan fine sandy loam ($\leq$ 1% OM) at the Wiregrass Research and Extension Center, Headland, AL (located in southeastern Alabama), on a site maintained in a peanut – cotton rotation. In 2003, the late-maturing peanut cultivar DP-1 was planted, which was then discontinued, and replaced with the late-maturing peanut cultivar C-99R in 2004 and 2005. Each of these cultivars have partial resistance to both leaf spot diseases and stem rot (Branch and Culbreath, 2008; Gorbet and Shokes, 2002; Hagan *et al.*, 2005). In late March, the field plot area was moldboard plowed and disked prior

Table 1. Fungicide application rates and timing for four scheduling strategies in 2003, 2004, and 2005.

Program	Schedule	Fungicide	Application Timing (DAP)[x]		
			2003	2004	2005
Chlorothalonil	2-wk	Chlorothalonil[y]	33, 47, 61, 75, 89, 103, 117	31, 45, 59, 71, 87, 101, 115	24, 43, 65, 79, 90, 108
	3-wk	Chlorothalonil	33, 54, 75, 96, 117	31, 52, 87, 94, 115	24, 43, 65, 90, 108
	4-wk	Chlorothalonil	33, 61, 93, 117	31, 59, 94, 115	24, 52, 90, 108
	AU-Pnuts[z]	Chlorothalonil	33, 47, 61, 82, 92, 106	41, 53, 71, 87, 110, 121	24. 43. 60. 90, 108
Tebuconazole	2-wk	Chlorothalonil	33, 47, 117	31, 45, 115	24, 108
		Tebuconazole	61, 75, 89, 103	59, 71, 87, 101	43, 65, 79, 90
	3-wk	Chlorothalonil	33, 117	31, 115	24, 108
		Tebuconazole	54, 75, 96	52, 87, 94	43, 65, 90
	4-wk	Chlorothalonil	33, 117	31, 115	24, 108
		Tebuconazole	61, 93	59, 94	52, 90
	AU-Pnuts	Chlorothalonil	33, 47	41, 121	24, 108
		Tebuconazole	61, 82, 92, 106	53, 71, 87, 110	43, 60, 90
Azoxystrobin	2-wk	Chlorothalonil	33, 47, 75, 103, 117	31, 45, 71, 101, 115	24, 43, 79, 108
		Azoxystrobin	61, 89	59, 87	65, 90
	3-wk	Chlorothalonil	33, 75, 117	31, 87, 115	24, 43, 108
		Azoxystrobin	54, 96	52, 94	65, 90
	4-wk	Chlorothalonil	33, 117	31, 115	24, 108
		Azoxystrobin	61, 93	59, 94	52, 90
	AU-Pnuts	Chlorothalonil	33, 47, 82, 106	41, 71, 110, 121	24, 43, 108
		Azoxystrobin	61, 92	53, 87	60, 90

[x]DAP = days after 14 May 2003, 16 May 2004, and 23 May 2005 planting dates.
[y]Application rates for chlorothalonil, tebuconazole, and azoxystrobin were 1.26, 0.26, and 0.34 kg ai/ha, respectively.
[z]AU-Pnuts advisory rules recommends fungicide applications using daily rainfall totals and 5-d rainfall forecast.

to planting. Aldicarb [Temik 15G, Bayer CropScience, Research Triangle Park, NC] at 1.1 kg ai/ha was applied in-furrow to control thrips. Weed control recommendations were according to Alabama Cooperative Extension System recommendations (Weeks *et al.*, 2008). In addition, escape weeds were pulled by hand or killed by cultivating the row middles. Due to frequent summer rains in 2003, the test area was not irrigated. In 2004, 2.8 cm/ha of water was applied on 30 July and 17 Aug., while in 2005 1.7 and 2.5 cm/ha water was applied on 1 Aug. and 13 Sept., respectively.

A randomized complete block design with four replications per treatment was used. Plots consisted of four 9.2 m rows spaced 0.9 m apart. For the azoxystrobin, chlorothalonil, and tebuconazole programs, applications were scheduled at 2-wk intervals, extended 3 and 4-wk intervals, and according to the AU-Pnuts leaf spot advisory. The 2-wk calendar schedule, which is the standard fungicide program for peanuts, served as the positive control.

In all three years, tebuconazole [Folicur 3.6F, Bayer CropScience, Research Triangle Park, NC] at 0.23 kg ai/ha was applied four times in the 2-wk schedule, 3 times in the 3-wk schedule, and 2 times in the 4-wk schedule, and 3 (2005) or 4 (2003 and 2004) times for the AU-Pnuts advisory. For all azoxystrobin [Abound 2SC, Syngenta Crop Protection, Greensboro, NC] programs, two applications of this fungicide at 0.34 kg ai/ha were made approximately 60 and 90 DAP in all years, as per product label requirements. Chlorothalonil [Bravo Ultrex, Syngenta Crop Protection, Greensboro, NC] at 1.26 kg ai/ha was applied at all other treatment times in the tebuconazole and azoxystrobin programs. Chlorothalonil at 1.26 kg ai/ha was also evaluated with application schedules of 2, 3, 4-wk intervals and according to the AU-Pnuts advisory. Application schedules for each fungicide treatment are presented in Table 1. Fungicides were applied with a four-row tractor-mounted boom sprayer with three TeeJet® TX-8 nozzles [Spraying Systems Co., Wheaton, IL] per row that delivered approximately 140 L/ha of spray volume at approximately 400 kPa.

Early and late leaf spot were rated together using the Florida peanut leaf spot rating scale where 1 = no disease, 2 = very few lesions on leaves in lower canopy, 3 = few lesions on leaves in lower and upper canopy, 4 = some lesions on leaves in lower and upper canopy with ≤10% defoliation), 5 = lesions noticeable in upper canopy and ≤25% defoliation, 6 = lesions numerous with ≤50% defoliation, 7 = lesions very numerous with ≤75% defoliation, 8 = numerous lesions on few remaining leaves with ≤90% defoliation, 9 =

remaining leaves covered with lesions with ≤95% defoliation, and 10 = plants defoliated or dead (Chiteka *et al.*, 1988). Final early leaf spot ratings, which were recorded on 25 Sept. 2003, 7 Oct. 2004, and 27 Sept. 2005, were used to compare fungicide treatments. Digging date was determined using the hull scrape method for assessing pod maturity as described by Williams and Drexler (1981). Stem rot ratings were taken from the center two rows immediately after the plots were dug on 13 Oct. 2003, 14 Oct. 2004, and 20 Oct. 2005. Incidence of stem rot was determined by counting the number of disease loci where a locus was ≤ 30.5 cm section of consecutively symptomatic plants in a row (Rodriguez-Kabana *et al.*, 1975). Plots were threshed two or three days later and then dried. Yields, which were taken from the two center rows of each four-row plot, were recorded at 10% moisture content.

Fungicide program, application schedule, and year effects on leaf spot diseases, stem rot, and yield in each trial were tested by analysis of variance. Within each year, fungicide program and application schedules were analyzed as a 3 × 4 factorial for effects on final leaf spot, stem rot and yield. Means were compared with the least significant difference (LSD) test at P=0.05 (SAS Institute) or as stated otherwise. Individual treatments were compared using contrast analysis. Net returns for each treatment were calculated by applying an appropriate price to the harvested yield from each treatment and subtracting production costs. Production costs were calculated as treatment material and application costs plus other typical peanut production expenses (Runge, 2009).

Results

In all three years, early leaf spot was the dominant leaf spot disease observed on both DP-1 and C-99R. Year and fungicide treatment interaction for early leaf spot (P = 0.0001) and stem rot (P = 0.0001) were significant, while the interaction of year and fungicide treatment was significant for yield if P < 0.10 (P = 0.091) (Table 2). Therefore, data for each year were analyzed and are presented separately.

In 2003 and 2004, the number of fungicide applications for the 2, 3, and 4-wk schedules were seven, five, and four, respectively, while six applications were made according to the AU-Pnuts advisory. In 2005, six, five, and four fungicide applications were applied at 2, 3, and 4-wk calendar schedules, respectively, and five applications were scheduled by the AU-Pnuts advisory.

Table 2. Analysis of variance values for leaf spot intensity, stem rot incidence, and peanut yield as influenced by year and fungicide treatment.

ANOVA Source	Leaf spot intensity	Stem rot	Yield
	F value		
Year	64.0***[z]	10.2**	3.3
Rep (year)	0.6	3.6***	2.0*
Fungicide treatment	2.3*	1.7	3.4***
Fungicide treatment x year	3.2***	3.1***	1.5

[z]Significance at 0.05, 0.01, and 0.001 is indicated by *, **, and ***, respectively.

In 2003 and 2004, fungicide program and application schedule each had significant (P < 0.003) effects on early leaf spot; the interaction of fungicide program x application schedule on leaf spot was not significant in either year. Neither fungicide program or application schedule nor the two-way interaction had a significant effect (P > 0.07) on early leaf spot in 2005. In 2003, the azoxystrobin and tebuconazole programs controlled early leaf spot better than chlorothalonil, while tebuconazole gave poorer disease control in 2004 compared with azoxystrobin and chlorothalonil (Table 3). For managing early leaf spot, the 2-wk application schedule was superior in both 2003 and 2004 to the 3 and 4-wk schedules (P < 0.024). In 2003, fungicide applications made according to the AU-Pnuts advisory provided less early leaf spot control compared to the 2-wk schedule (P = 0.015),

Table 3. Main effects of fungicide programs and application schedules on final leaf spot ratings[w] on the peanut cultivars DP-1 (2003) and C-99R (2004 and 2005).

	2003	2004	2005
Fungicide Program			
Chlorothalonil	4.8[x]	4.3	4.5
Tebuconazole	4.2	4.6	4.3
Azoxystrobin	4.1	4.1	4.2
LSD (P=0.05)	0.3	0.3	NS[y]
Application Schedule			
2-wk	3.2	3.9	4.2
3-wk	5.2	4.6	4.5
4-wk	4.4	5.1	4.5
AU-Pnuts[z]	4.4	3.7	4.1
LSD (P=0.05)	0.3	0.3	NS

[w]Rating for early and late leaf spot on a scale of 1 to 10, with 10 = plants defoliated or dead.

[x]Mean separation in each column was according to analysis of variance and least significant difference (LSD) test (P=0.05).

[y]NS = not significant.

[z]AU-Pnuts advisory rules recommends fungicide applications using daily rainfall totals and 5-d rainfall forecast.

Table 4. Main effects of fungicide programs and application schedules on stem rot incidence[x] on the peanut cultivars DP-1 (2003) and C-99R (2004 and 2005).

	2003	2004	2005
	loci/20 m		
Fungicide Program			
Chlorothalonil	5.9[y]	8.7	3.5
Tebuconazole	5.1	6.1	3.8
Azoxystrobin	4.6	4.1	3.2
LSD (P=0.05)	1.0	1.4	NS[z]
Application Schedule			
2-wk	5.1	4.9	3.0
3-wk	6.0	7.5	3.6
4-wk	4.2	6.6	4.0
AU-Pnuts	5.5	6.2	3.6
LSD (P=0.05)	1.1	1.6	NS

[x]Stem rot incidence is the number of disease loci (a locus is ≤ 30.5 cm section of consecutively symptomatic plants in a row) per 20 m of row.

[y]Mean separation in each column was according to analysis of variance and least significant difference (LSD) test (P=0.05).

[z]NS = not significant.

Table 5. Main effects of fungicide programs and application schedules on yields on the peanut cultivars DP-1 (2003) and C-99R (2004 and 2005).

	2003	2004	2005
	kg/ha		
Fungicide Program			
Chlorothalonil	4110[y]	3895	3754
Tebuconazole	4213	4473	4269
Azoxystrobin	4714	4892	4198
LSD (P=0.05)	290	280	454
Application Schedule			
2-wk	4449	4626	4218
3-wk	4153	4320	4092
4-wk	4542	4234	3735
AU-Pnuts	4239	4499	4250
LSD (P=0.05)	335	324	NS[z]

[y]Mean separation in each column was according to analysis of variance and least significant difference (LSD) test (P=0.05).

[z]NS = not significant.

while in 2004, early leaf spot ratings for the 2-wk and AU-Pnuts schedules were similar ($P > 0.33$). Fungicide program and application schedule had no effect on leaf spot in 2005.

In 2003 and 2004, fungicide program and application schedule each had a significant ($P < 0.03$) effect on stem rot incidence. The fungicide program x application schedule interaction, which was significant ($P = 0.009$) only in 2003, is likely due to very low incidence of stem rot recorded in the 4-wk azoxystrobin treatments compared with the other 4-wk fungicide programs. Fungicide program, application timing, nor the interaction of these two factors had a significant effect ($P > 0.40$) on stem rot in 2005. When compared with the chlorothalonil program, stem rot incidence was lower for the azoxystrobin program in 2003 and 2004, and with the tebuconazole program in 2004 (Table 4). The 2-wk application schedule provided better control of stem rot than the other calendar schedules in 2004. The 4-wk application schedules were better for controlling stem rot than the 3-wk schedule or AU-Pnuts advisory in 2003. In all three years, the AU-Pnuts advisory and 2-wk schedules provided similar stem rot control.

In both 2003 and 2004, yield was significantly affected by fungicide program ($P < 0.0004$), and by application schedule if $P < 0.10$ ($P = 0.086$ and $P = 0.081$, respectively). In 2005, fungicide program was significant in affecting yield if $P < 0.10$ ($P = 0.056$) but application schedule ($P = 0.189$) was not. Yield was higher with azoxystrobin than with the other fungicide programs in 2003 and 2004, while the tebuconazole programs had higher yields compared with chlorothalonil in 2004 and 2005 (Table 5). Among application schedules, there were no consistent significant effects on yield.

When yields were combined over years and analyzed, significant differences were noted due to application schedules ($P < 0.0001$), while fungicide programs were nearly significant ($P = 0.067$). The 4-wk schedules had significantly lower yields, by 261 kg/ha, than the 2-wk schedule, which produced 4431 kg/ha. No significant difference in yield was noted between the 2 wk, 3 wk, and the AU-Pnuts advisory schedules. Net returns for the 2, 3, and 4-wk schedules as well as the AU-Pnuts advisory across all fungicide programs, which were \$267, \$258, \$302, and \$279/ha, respectively, did not significantly differ. Higher yields were obtained with tebuconazole and azoxystrobin programs by 392 and 669 kg/ha, respectively, than chlorothalonil alone. However, despite differences in yield, net returns of \$218, \$287, and \$324/ha for the azoxystrobin, chlorothalonil, and tebuconazole programs, respectively, did not significantly differ.

Discussion

This study compared three fungicide programs (chlorothalonil-alone, chlorothalonil/tebuconazole, and chlorothalonil/azoxystrobin), applied on four schedules and on partially disease resistant cultivars. The inclusion of tebuconazole programs in this study builds on our previously published report (Bowen *et al.*, 2006) in which reduced application fungicide programs with azoxystrobin were compared for disease control and yield. Fewer fungicide applications were applied when the AU-Pnuts advisory was implemented for this study, compared to a 2-wk application schedule, and this situation did not occur for our previous study done in southwest Alabama (Hagan *et al.*, 2006). In addition, AU-Pnuts fungicide programs were often as effective for controlling early leaf spot and stem rot, while maintaining peanut yield as were the 2-wk application schedules. Similar results have also been noted by others (Brenneman and Culbreath, 1994; Jacobi and Backman, 1995) using the discontinued cultivar Southern Runner. In addition, results of the current study confirm previous reports that tebuconazole (Brenneman and Culbreath, 1994; Grichar *et al.*, 2005; Nuti *et al.*, 2008) and azoxystrobin (Bowen *et al.*, 2006; Grichar *et al.*, 2005) often give similar leaf spot and stem rot control when applied according to the AU-Pnuts advisory versus a 2-wk schedule. When applied on 2-wk intervals, azoxystrobin and tebuconazole programs have often been shown to be equal in terms of peanut disease and yield management (Hagan *et al.*, 2004; Jaks and Grichar, 2004; Phipps and Partridge, 2007; Shew, 2004). As was seen in the current study, reducing the number of applications of tebuconazole in a calendar or advisory schedule below the recommended four did not have a negative impact on leaf spot or stem rot control (Bowen *et al.*, 1997; Brenneman and Culbreath, 1994; Gricher *et al.*, 2005; Hagan *et al.*, 2006; Jaks and Gricher, 2004; Phipps and Partridge, 2007). Previously, Bowen *et al.* (1997) reported that between three and four applications of tebuconazole were best for disease control and maximum yield of Florunner peanut. We did see a slight benefit to the use of azoxystrobin in terms of improved yield in 2 of 3 study years, compared to tebuconazole. However, the difference in yield response may be due to the reduction in tebuconazole application numbers (4, 3 and 2 applications in the 2, 3 and 4-wk schedules, respectively) compared with two azoxystrobin applications included in all treatment schedules with this fungicide.

Extending application intervals is another strategy for reducing fungicide application numbers. Previously, increased damage from one or both leaf spot diseases had been observed when application intervals were lengthened beyond the recommended 2-wk interval on susceptible as well as leaf spot resistant cultivars (Brenneman and Culbreath, 1994; Monfort *et al.*, 2004; Woodward *et al.*, 2008). Brenneman and Culbreath (1994) noted that severe leaf spot outbreaks, which resulted from extending application intervals from 2 to 3 wk, did not always result in lower yield. In the current study, poorer control of early leaf spot for the 3 wk compared with the 2-wk schedules was seen in two out of three years; however, the reduction in disease control did not result in lower yield. A similar decline in early leaf spot control was noted by Monfort *et al.* (2004) when application intervals were extended beyond 2 wk, but there was not a consistent reduction in yield of C-99R or Florida MDR-98, another leaf spot-resistant cultivar. However, Monfort *et al.* (2004) observed that the leaf spot-susceptible cultivar, Georgia Green, had higher yield with an azoxystrobin than a tebuconazole extended interval program. Results reported by Monfort *et al.* (2004) stressed the importance of cultivar resistance on the effectiveness of a reduced fungicide application program.

Extending application intervals from 2 wk to 4 wk reduced control of early leaf spot in 2 of 3 years, regardless of fungicide program. Stem rot incidence and yield, however, were similar for the 2- and 4-wk schedules in 2 of 3 years. These results are similar to those previously reported by Bowen *et al.* (2006) on the disease resistant cultivars C-99R and DP-1 where lengthening application intervals with azoxystrobin from 2 to 4 wk led to a decline in early leaf spot control, but yield declined in only one of three years. Hagan *et al.* (2006) reported that yields of DP-1 and C-99R declined in two of three years when application intervals with azoxystrobin, tebuconazole, and chlorothalonil programs were extended from 2 to 4 wk. The latter study was done in southwest Alabama, a wetter and more disease conductive environment than the traditional peanut production region in southeast Alabama. Together these studies demonstrate that extended fungicide application intervals when combined with a disease resistant cultivar is a simpler method of reducing fungicide inputs than implementation of a weather-based advisory. Indeed, results of the current study demonstrate that while leaf spot severity may be greater when fungicides are applied at 3-wk intervals or AU-Pnuts scheduling, stem rot incidences and yields do not differ. The frequency of significant yield losses associated with extended application intervals would likely be greater on leaf spot- and stem rot-susceptible cultivars such as Georgia Green (Branch and Culbreath, 2008; Hagan *et al.*, 2005; Monfort *et al.*, 2004; Woodward *et al.*, 2008).

Due in part to low disease pressure, stem rot was not greatly influenced by fungicide program or application interval in the current study. Bowen *et al.* (2006) also did not see a consistent effect of calendar application schedule on stem rot control with azoxystrobin programs. For all fungicides in all three years in the current study, stem rot control obtained with the 2 wk and AU-Pnuts advisory was similar. These results suggest that stem rot can be managed adequately using efficacious fungicides when applied at extended intervals or according to the AU-Pnuts advisory. Even with the reductions in numbers of fungicide applications, yields were generally similar among application schedules. Finally, we did not see a decline in net income.

Due to increased operating costs and low peanut prices, industry sources indicate that Alabama peanut producers have reduced fungicide application numbers or rates. The AU-Pnuts leaf spot advisory has been shown in this and in previous studies (Bowen *et al.*, 2006; Brenneman and Culbreath, 1994; Grichar *et al.*, 2005; Jaks and Gricher, 2005; Jacobi and Backman, 1995; Jacobi *et al.*, 1995; Phipps and Partridge, 2007; Shew, 2004) to be an effective tool for maximizing fungicide benefits, while often reducing application numbers. Despite the availability of web-based site-specific rainfall data and weather forecasts to aid in the implementation of AU-Pnuts, this advisory program is not used by Alabama peanut producers (Hagan, personal observation). Among the constraints cited by Campbell and Madden (1990) that may limit the adoption of weather based advisories are the time and bookkeeping required to monitor weather variables as well as insufficient labor and equipment to make timely advisory-recommended fungicide applications on short notice. Bailey *et al.* (1994) also cites application logistics as being an impediment to the successful adoption of weather-based peanut spray advisories. In each year of this study, one chlorothalonil or tebuconazole application was saved with AU-Pnuts compared with the 2-wk calendar schedule. The saving of approximately \$15/ha for 1.26 kg ai of generic chlorothalonil or \$20/ha for 0.26 kg ai of generic tebuconazole plus application costs is apparently insufficient to justify the time, labor, and logistics required to run AU-Pnuts. For the Alabama producers maintaining numerous, small and usually rain-fed peanut fields, extending fungicide application intervals from 2 to 3 wk on a disease resistant cultivar would be simpler and effective alternative to AU-Pnuts for managing leaf spot diseases and stem rot.

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